

MONTHLY WEATHER REVIEW.

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ANNUAL REPORT BY WILLIS L. MOORE, CHIEF OF THE WEATHER BUREAU, FOR THE FISCAL YEAR ENDING JUNE 30, 1906.¹

[Dated August 30. Extract from the report of the Secretary of Agriculture, issued December 15, 1906.]

I have the honor to submit a report of the operations of the Weather Bureau during the fiscal year that ended June 30, 1906.

OPERATIONS OF THE YEAR.

FORECASTS AND WARNINGS.

Weather forecasts for thirty-six and forty-eight hours in advance have been made daily thruout the year for each State and Territory, and special warnings of gales on the seacoasts, Gulf, and Great Lakes, and of cold waves, frosts, heavy snows, floods, etc., have been issued when the advices were calculated to benefit commercial and agricultural interests. The North Atlantic and West Indian storm-warning service was continued, and forecasts for the first two days out for steamers bound for European ports were issued daily at 8 a. m. and 8 p. m. The work of the Forecast Division is under the special supervision of Prof. E. B. Garriott; the River and Flood Service is in charge of Prof. H. C. Frankenfield.

The material necessary in the forecast and warning service has been gathered twice daily by telegraph and cable from about 160 stations in the United States, 19 in Canada, and about 20 in the islands of the Atlantic and on the western coast of Europe; in all, about 200 reports have been received in the morning and a lesser number in the evening. Eight forecast centers have been maintained, as follows:

Washington, D. C.—A. J. Henry, Professor and National Forecaster; H. C. Frankenfield, Professor and National Forecaster.

Boston, Mass.—John W. Smith, District Forecaster.

New Orleans, La.—I. M. Cline, District Forecaster.

Louisville, Ky.—F. J. Walz, District Forecaster.

Chicago, Ill.—H. J. Cox, Professor and District Forecaster.

Denver, Colo.—F. H. Brandenburg, District Forecaster.

San Francisco, Cal.—A. G. McAdie, Professor and District Forecaster.

Portland, Oreg.—E. A. Beals, District Forecaster.

Altho no important change has been made during the year, either in the character of the available material or in the manner of its application to the problem in hand, constant effort has been put forth to improve the forecast service. In another portion of this report reference will be made to the work accomplished in the way of seeking new physical data, both solar and terrestrial, in the hope of successfully applying them to weather forecasting.

It was the hope of leading meteorologists some twenty years ago that a study of the pressure distribution over the globe, especially the shifting of great air masses in latitude and longitude, would yield valuable results. In more recent years

the subject has been further pursued and a fairly close relation has been established between the pressure distribution over the Atlantic and the character of the weather over western Europe. In this country studies of atmospheric pressure distribution in the United States in its relation to long-period fluctuations in temperature and rainfall have been made by Garriott, Fassig, Henry, and McAdie. In general, however, these studies did not attempt to deal with the relation between current weather conditions and pressure distribution over continental and oceanic areas, for the reason that daily barometric readings from oceanic areas were not available. Cable connection with the Azores was effected a year or so since, and within the year just closed communication with Honolulu was established. Reports from these stations, including Bermuda and the west coast of Europe, throw considerable light upon the atmospheric movements in the United States, and the study of these movements in the light thus afforded is the distinctive work of the year. The result has been sufficiently encouraging to warrant its further prosecution and a still further enlargement of the field of view by the courtesy of foreign meteorological services.

ENLARGEMENT OF THE FIELD OF OBSERVATION.

Already correspondence has been entered into with the director of the physical observatory, St. Petersburg, Russia, with a view to securing daily reports from Siberia, the seat of the great winter area of high pressure in the Northern Hemisphere.

The Bureau also has in preparation a plan of organization for a service in Alaska by means of which prompt advices may be received of changes in the Bering Sea area of low pressure, which are intimately associated with the weather of the United States.

The extension of the field of observation over the adjacent oceans is not yet fully developed. The essential features of this service provide for the collection, by means of wireless telegraphy, of simultaneous meteorological observations from vessels at sea, and the dispatch of weather forecasts and storm warnings to all vessels within the zone of communication that are equipped with wireless apparatus. The details of the plan have been worked out, and arrangements have been made with the Marconi Wireless Telegraph Company of America and with the American De Forrest Wireless Telegraph Company to transmit the observations from the vessels to the Weather Bureau at a stipulated rate; also to transmit weather forecasts and storm warnings from the Weather Bureau to vessels at sea without charge.

This service is under the direction of the Division of Ocean Meteorology, and was placed in tentative operation aboard the vessels of the American Line December 1, 1905, the first dispatch being received from the steamship *New York*, Captain

¹ Reprinted with a few verbal alterations for publication in the Monthly Weather Review, for the information of cooperative observers and foreign correspondents.—EDITOR.

Roberts, December 3, the position of the vessel at the time being latitude 40° N., longitude 60° W., or about 600 miles east of Sandy Hook.

Subsequently the service was extended to the following-named vessels of other lines, all equipped with the Marconi apparatus, viz:

North German Lloyd: Steamships *Grosser Kurfurst*, *Kaiser Wilhelm II*, *Kaiser Wilhelm der Grosse*, *Kronprinz Wilhelm*.

Hamburg American Line: Steamships *Amerika*, *Bluecher*, *Deutschland*, *Kaiserin Augusta Victoria*.

Cunard Line: Steamships *Campania*, *Carmania*, *Caronia*, *Carpathia*, *Etruria*, *Ivernia*, *Lucania*, *Pannonia*, *Slavonia*, *Ullonia*, *Umbria*.

White Star Line: Steamships *Baltic*, *Cedric*, *Celtic*, *Majestic*, *Oceanic*.

Compagnie Generale Transatlantique: Steamships *La Bretagne*, *La Lorraine*, *La Provence*, *La Savoie*, *La Touraine*.

All the above-named vessels, including the steamships *New York*, *Philadelphia*, *St. Paul*, and *St. Louis*, of the American Line, are now authorized to transmit their daily Greenwich mean noon observations to the Bureau.

The privilege has also been extended to the following vessels equipped with the De Forrest system:

Panama Railroad and Steamship Line: Steamships *Advance*, *Allianca*, *Colon*, *Finance*, *Panama*.

Mallory Line (New York to Galveston): Steamships *Concho*, *Denver*, *San Jacinto*.

The service and code have also been adopted by the U. S. Navy Department, and all vessels of the U. S. Navy are instructed to transmit the daily weather dispatch while at sea. The wireless telegraph stations controlled by the Navy Department are also required to receive weather messages from merchant vessels and to transmit them to the Bureau, likewise to dispatch the weather forecasts and storm warnings issued by the Bureau to vessels at sea demanding them, free of cost.

The service in connection with the merchant marine is not yet in good working order, owing to its novelty, the inexperience of both observers and operators, and other considerations of a financial character.

EXTENSION OF STORM-WARNING SERVICE.

The storm-warning service has now been extended to include all wireless telegraph stations of the Navy Department along the coasts of the Atlantic, the Pacific, and the Gulf of Mexico. These stations receive storm-warning messages from the Weather Bureau and transmit them to light-ships and vessels in the zone of communication that are equipped with wireless apparatus. A similar service has also been inaugurated with the Marconi company by means of which its stations transmit to vessels equipped with the Marconi apparatus messages containing storm advices.

Ten additional storm-warning display stations have been furnished with steel towers and high-power lanterns for night displays. One hundred and seventy-two display stations on the Lake, Gulf, and seacoasts of the United States are now provided with improved apparatus for the better display of storm warnings. No station of any importance to shipping and commercial interests remains to be equipped, and this important work, which was begun in 1900, is now practically complete.

STORMS OF THE YEAR.

The most important and only severe tropical storm of the year advanced from the Caribbean Sea, south of San Domingo, northward over the eastern Bahamas, and thence northeastward over the Atlantic Ocean during the early part of October, 1905. On the 11th, when this storm was central near the eastern edge of the banks of Newfoundland, the steamship *La Savoie* reported the remarkable barometer reading of 27.92 inches, and the steamship *Campania* encountered a disastrous storm wave. Advices to West Indian, Atlantic, and Gulf coast

interests regarding the storm were begun with its first appearance over the Caribbean Sea and continued daily until it recurred northeastward over the Atlantic Ocean, when advices to Canadian maritime ports were begun and continued until the center passed Bermuda. Lloyds, London, was also advised that a severe tropical storm was moving from Bermuda north-eastward toward the trans-Atlantic steamship routes.

In the autumn of 1905 the Lake region was visited by several storms of exceptional severity, in connection with which the work of the Weather Bureau was conspicuously valuable. Ample and timely warnings were issued of severe cold waves and damaging frosts, and, in the Southern States especially, the advices were of great value to garden and trucking interests.

A notable advance in the frost-warning service has been made in the cranberry districts of Wisconsin, Massachusetts, and New Jersey, where special observations of air and soil temperatures are being utilized to improve the accuracy of the forecasts during the growing season.

RIVER SERVICE.

No important floods occurred during the year. Action has been taken to extend the river and flood service in California and South Carolina, and the river and special rainfall stations of the country as a whole have been improved as the needs of the service demanded and the fund permitted.

DISTRIBUTION OF FORECASTS AND SPECIAL WARNINGS.

First and foremost in the effective distribution of daily weather forecasts and special warnings are the daily newspapers and the various press associations. Closely following these in importance is the telephone, not only in rural districts but also in the great centers of population. During the year just ended over half a million telephones were added to those already receiving forecasts and warnings thru the telephone exchanges.

Aside from the distribution thru the press associations, the daily newspapers, and the telephone, it has been found necessary to telegraph forecasts and warnings direct to a number of places in the different States and Territories at the expense of the Bureau, it being impossible to serve the interests involved thru the press associations. The number of addresses in the United States to which forecasts and special warnings are sent by telegraph is 2150. Special warnings only are sent to 767 addresses, and emergency warnings, when issued, to 5998 addresses. Distribution without expense to the Bureau is made to 76,719 addresses by mail, to 82,466 by mail thru the rural free-delivery service, to 1,014,285 by telephone, to 2,145 by railroad telegraph lines, and to 2,514 by railroad train service.

INCREASE IN THE NUMBER OF METEOROLOGICAL STATIONS IN THE UNITED STATES.

This report would be incomplete without mention of the great increase in the administrative work involved in the operation and maintenance of a central office in the city of Washington and 187 first-order stations at various outlying points, the latter employing in all 513 persons. The number of first-order stations ten years ago was 131. The increase is due to a constantly growing demand for weather information from various parts of the country hitherto not occupied by a reporting station of the Bureau. Aside from the stations above named, the Bureau employs nearly 900 persons at nominal salaries for the following purposes, viz, 160 for the display of storm warnings along the seacoasts and the Great Lakes; 340 persons in taking observations of river stages and rainfall; 107 persons in taking rainfall observations on the headwaters of various streams; 154 persons in taking observations of the weather in the cotton-growing States; 133 persons in taking observations of the weather in the corn and wheat growing States; in all, 897 noncommissioned employees, each of whom, however, devotes probably less than half an hour daily to the service of the Bureau.

In addition to the above, the climatic conditions in the United States and its outlying possessions are being recorded at about 3700 points known as cooperative stations. The most important climatic elements, viz, temperature and precipitation, are observed at these stations with standard instruments, and the general weather conditions are carefully noted and recorded. The total number of points within the United States, at which observations suitable for a discussion of the climatic conditions of the country are taken, is therefore about 4500.

ESTABLISHMENT OF NEW CLIMATIC STATIONS AT HIGH LEVELS.

An effort was made during the year to establish, thru the cooperation of the Forest Service of this Department, a number of stations on the mountain ranges, with a view of determining the amount of precipitation and the temperature conditions at high levels. Thus far the results have not come up to expectation.

THE DISTRIBUTION OF METEOROLOGICAL INFORMATION.

The immense output of meteorological information that comes from the various stations maintained by the Bureau is exhibited to the public in various ways. The daily output finds its way to the public mainly thru the columns of the newspapers and in the maps and bulletins issued at Washington and outlying stations. The daily issue of maps in Washington is about 1625 copies. Outside of Washington there are 105 stations, which issue an aggregate of 25,000 maps daily, making a yearly issue of over 8,000,000 copies.

During the crop-growing season a weekly résumé of the weather conditions in all parts of the country is printed and distributed in the form of State and National weather bulletins. The National Weather Bulletin, of which 2500 copies were issued June 30, 1906, contains a statement of the weather conditions over the entire country; while the State or district bulletins, of which 31,190 were issued at 44 centers on June 30, 1906, give a résumé of the weather conditions in the State or district only.

CHANGE IN NATIONAL AND STATE BULLETINS.

During the year all matter relating to crop conditions was eliminated from the weekly and monthly weather bulletins issued at the section centers, and at Washington, D. C., in order that more emphasis could be placed upon the meteorological conditions prevailing in the various States and Territories.

PRINTED REPORTS OF WEATHER CONDITIONS.

As above stated, the daily weather conditions are printed in some detail on the daily weather maps, but inasmuch as the supply of maps is necessarily limited and there is no issue on Sundays or holidays, each section center, of which there are 44, prints a monthly summary of weather conditions, including a statement of the highest and the lowest temperatures and the total precipitation for each day of the month, so that the important climatic features in all parts of the country are made of record and can be found in print.

The number of monthly climatological reports printed at the various section centers is 30,944, being an average of about 700 copies each per month. The work of the Climatological Division is intrusted to Mr. James Berry, Chief of Division.

MONTHLY WEATHER REVIEW.

In the same category, but on a somewhat larger scale, the Weather Bureau publishes in the MONTHLY WEATHER REVIEW a résumé of the weather in the United States, as shown by the reports of about 4500 stations. This publication has been issued regularly under the editorship of Professor Abbe. In addition to the climatological tables and charts, it contains a report on the work relating to forecasts and warnings, rivers and floods, and a summary of the weather for the month. It is also a medium of communication for the exchange between members of the service of views and experiences in Weather Bureau work. Distinguished meteorologists outside of the

service have freely contributed to its columns, so that it has become recognized as an important aid to the officials of the Bureau.

METEOROLOGY OF THE OCEANS.

As stated in my last report, the control of meteorological work on the oceans was transferred from the Navy Department to the Department of Agriculture, and assigned to the Weather Bureau. The function of the Weather Bureau in the matter of meteorological observations over the oceans is the collection of information respecting atmospheric disturbances, winds, temperature, densities, ice conditions; the prevailing weather on sailing and steamship routes; and the reduction and publication of this information in such form as will prove of the highest value to commerce and navigation.

The information in question is obtained entirely thru a system of voluntary cooperation with the Bureau on the part of the navy and merchant marine of every maritime nationality on the globe, a specifically designated observer aboard each cooperating vessel being under instructions from the master to furnish the Bureau with certain daily observations; the Bureau, in return, furnishing the master of such vessel and the observer with a copy of such publications as may be founded on the observations in question.

Instructions to the local offices of the Weather Bureau interested in the conduct of the work were issued early in the year by Mr. James Page, in charge of the Division of Ocean Meteorology. These offices are at present as follows:

Portland, Me.	New Orleans, La.	Tampa, Fla.
Boston, Mass.	Galveston, Tex.	Seattle, Wash.
New York, N. Y.	Tacoma, Wash.	Portland, Oreg.
Philadelphia, Pa.	Wilmington, N. C.	San Francisco, Cal.
Baltimore, Md.	Charleston, S. C.	San Diego, Cal.
Norfolk, Va.	Jacksonville, Fla.	Honolulu, H. I.
Pensacola, Fla.	Savannah, Ga.	
Mobile, Ala.	Key West, Fla.	

The number of weather reports received during the year was 8160, and their geographical distribution covering the period July, 1905, to June, 1906, inclusive, was as follows: North Atlantic Ocean, 6555; South Atlantic Ocean, 441; North Pacific Ocean, 1030; South Pacific Ocean, 327; Indian Ocean, 110. The number of vessels reporting was 1771.

MOUNT WEATHER RESEARCH OBSERVATORY.

The meteorological work of a first order station has been maintained thruout the year, and telegraphic reports were transmitted to the Central Office in Washington daily at 8 a. m. and 8 p. m.

Work on the physical laboratory was resumed in July and satisfactory progress was made during the summer and fall of 1905. The building will probably be completed early in 1907.

In the preparation for kite and balloon work a number of important instruments have been installed and made ready for systematic work. Among these may be mentioned: (1) The electrolyzer, for the manufacture of the hydrogen gas employed in the kite balloon and the small rubber balloons; (2) the apparatus for the manufacture of liquid air, employed in testing thermometers at very low temperatures; (3) the apparatus used in testing the barometers, thermometers, and meteorographs employed in connection with the kites and balloons. A medium-sized power kite-reel was installed in the revolving kite-house early in the year, and experimental kiteflying was begun in September of 1905. During the year the stock of meteorographs, of kites, and of kite wire was materially increased; the instrumental equipment now includes eight different styles of kite-balloon meteorographs, comprising English, German, and French designs, in addition to the Marvin type heretofore used in the kite work of the Bureau, and the new Fergusson pattern used at the Blue Hill Observatory.

In April, 1906, systematic cooperation was begun in connection with the work of the International Committee for Scien-

tife Ballooning by flying kites on prearranged term days, and this work is being regularly maintained.

The interior finishings of the magnetic observatory buildings, the erection of the piers, and the installation of the magnetic instruments were completed during the year.

The instruments for absolute observations, except the declinometer and some auxiliary apparatus, were received and set up before January 1, 1906. The remaining absolute instruments were received and put in place by the end of May, and routine observations were established at the end of the fiscal year.

The Eschenhagen magnetographs were set up in the basement of the absolute observatory in December, 1905, and have given a satisfactory record of the magnetic elements since that time. The Wild magnetographs were received and installed by the first of June, and were being adjusted by the end of the fiscal year.

A gas plant for heating and illuminating the magnetic observatories was put in during the winter and has given satisfactory service since then.

Plans were prepared for an additional office and dwelling for the director of upper-air research, and work on this building was begun July 1, 1906.

SOLAR RADIATION.

From May 1 to November 27, 1905, Mr. H. H. Kimball was detailed for duty at the astrophysical observatory of the Smithsonian Institution. Here, thru the courtesy of the late Prof. S. P. Langley, in addition to maintaining solar-radiation observations with the Ångström pyrheliometer, and measurements of the maximum polarization of skylight with the Pickering polarimeter, comparisons were made between this pyrheliometer and the actinometers in use at the observatory, and valuable experience was obtained in the use of the bolometer and in the reduction of actinometric and bolometric observations. As a result of this experience the system under which solar-radiation observations have been maintained since April, 1903, has been materially modified.

SPANISH-ALGERIAN ECLIPSE EXPEDITION.

In compliance with the request of Rear-Admiral C. M. Chester, U. S. Navy, Superintendent of the Naval Observatory, for the Weather Bureau to cooperate in the expedition to observe the total eclipse of the sun, August 30, 1905, the meteorological work of the expedition was assigned to Prof. Frank H. Bigelow, with Dr. Stanislav Hanzlik as his principal assistant. Other assistants were appointed by Rear-Admiral Chester from among the naval force, and three primary stations were equipped and operated, viz, at Daroca, and Porto Coeli, in Spain, and Guelma, in Algeria. Secondary stations were established at Castellon, Tortosa, Zaragoza, and Guadalajara, in Spain, and at Bona, in Algeria. The Spanish officials extended every possible courtesy in facilitating the operations of the expedition. An extensive series of observations was secured during August, 1905, including the usual meteorological elements, the coefficient of dissipation, the ionization contents, and the potential gradient of the atmospheric electricity, the solar radiation and the polarization.

On the voyage between Hampton Roads and Gibraltar several kite ascensions were made over the ocean, and numerous electrical and polarization observations were secured.

A report of the results of the meteorological work of the expedition has been prepared by Professor Bigelow and transmitted to the Navy Department for publication with the report of the astronomical researches.

LIBRARY.

It is the aim of the librarian, Mr. H. H. Kimball, to obtain all standard works of reference and technical books on meteorology and allied sciences for the use of Weather Bureau officials in Washington and elsewhere; also, to collect and preserve printed climatological data from all parts of the world. While

many general reference books are of necessity duplicated in other government libraries, this is not the case with respect to purely meteorological and climatological works. Even the Library of Congress refers readers to the Weather Bureau library when extensive research along these lines is to be made.

Many important books and publications can only be obtained by purchase; but by far the greater number have been received in exchange for Weather Bureau publications, or given by authors and publishers. During the last year 416 were obtained by gift and exchange, while only 116 were purchased.

The work of extending the exchange system so as to include as nearly as possible all climatological data published thruout the world is now being systematically carried on. This literature will in time be fully cataloged and made accessible to students. For the present special attention is being paid to those regions of the world which have been least explored by meteorologists, and for which, therefore, such meteorological data as exist are in the greatest need of being collected and preserved. This climatological work is the special field of Mr. Talman, assistant librarian, who utilizes the rich resources of the library in preparing a monthly international review of climatology for the MONTHLY WEATHER REVIEW. Such work is undertaken primarily in response to the demands constantly made upon our library for information regarding meteorology of foreign lands, but it is also in accord with the spirit of international investigation which now prevails generally among progressive meteorologists.

Lists of the more important books added to the library, and of important papers relating to meteorology that have appeared in current periodicals, have been prepared for publication in each number of the MONTHLY WEATHER REVIEW.

METEOROLOGICAL RECORDS.

The Division of Meteorological Records and the Barometry Section have been united during the year and placed in charge of Prof. Frank H. Bigelow. The care of the manuscript records of the meteorological observations made thruout the service, the checking of the computations, the preparation of the tabular data for the MONTHLY WEATHER REVIEW and the annual report, and the supplying of the public with information, including the Federal Departments and Bureaus, State, county, and city officials, civil engineers, and many individuals, are in charge of this division. The discussion of the records and the compiling of data for scientific purposes, especially the relations of solar physics to meteorology, are carried on as far as practicable. Special attention is given at present to the temperature data, and tables of station normals based upon thirty-three years of observations reduced to a homogeneous system, together with the annual and monthly variations, are being prepared. At the same time similar data for the vapor pressure are being computed. These works, when finished, together with the barometry of the United States already published, will constitute a fundamental system of data upon which scientific studies of the variable climatic conditions may properly be based.

THE TEACHING OF METEOROLOGY.

The officials of the Weather Bureau have had their attention forcibly drawn to the teaching of meteorology by the increased recognition of that science as a branch of study appropriate to high schools, normal schools, colleges, and universities. In answer to circular letters sent out by Professor Abbe it would appear that elementary climatology, considered as a part of geography, is taught in about 1000 graded schools. Elementary climatology and meteorology are taught in connection with geology in about 7000 high schools, or seven-eighths of the whole number that are cataloged by the Bureau of Education.

Specific courses in meteorology or climatology are given in about 140 out of 177 public normal schools, altho in some of

these the subject is taught in connection with physical geography. Out of 311 colleges and universities from which direct replies have been received, 59 state that they have specific courses in meteorology, 133 teach this in connection with some other subject, and 119 pay no attention to it. The corresponding percentages are 19, 43, and 38, and probably the replies from other colleges will not alter these ratios very much. In fully one-half of these institutions, from the lower schools to the higher universities, some form of laboratory method is pursued—that is to say, students are required to make personal observations, experiments, and deductions. They study the daily weather map and develop habits of individual thought. In a matter so complex as the weather, no text-books can replace the daily map, personal observations, and independent study.

In addition to the popular work of the high schools and colleges, a higher class of work has been carried out by the scientific schools and universities. This special technical instruction is divided into two parts—that which is done by the scientific faculty as such and that which is done by Weather Bureau officials temporarily appointed as instructors, who sometimes do this educational work without extra compensation from the colleges. There are 19 of the latter and about 50 of the former.

Effort is being made to correlate and reduce to a uniform system the standard of instruction to be given at these institutions, so that, at least in some cases, these scientific schools may prepare men for the highest work that is required of a Weather Bureau official.

INSTRUMENTAL EQUIPMENT.

The Instrument Division, in charge of Prof. C. F. Marvin, supervises the equipment for the work of both regular and special stations.

Systematic efforts were continued during the year to bring as many as possible of the long-established telegraphic-reporting stations up to the uniform standard of equipment as now furnished new stations, and the instrumental outfits at Grand Haven, Mich.; Mobile, Ala.; Red Bluff, Cal.; North Platte, Nebr.; Baker City, Oreg.; Winnemucca, Nev., and Abilene, Tex., were completed. It is hoped to finish this work during the next fiscal year, as there still remain in the service only a few stations where the improved automatic self-recording instruments are required for climatological or local interests.

New stations at Anniston, Ala.; Thomasville, Ga.; Del Rio, Tex.; Iola, Kans.; Bentonville, Ark.; Burlington, Vt.; Tonopah, Nev., and Canton, N. Y., were completely equipped with new instruments, and a duplicate equipment was sent to San Jose and San Francisco, Cal., the equipments for the two last-named stations being required on account of the total destruction of the instruments formerly in use there by the disastrous earthquake and fire of April 18, 1906. These two stations were completely wiped out of existence in a few hours, involving the loss of several thousand dollars' worth of instruments and apparatus, to say nothing of valuable records and data that neither time nor money can replace.

INVESTIGATION OF FROST CONDITIONS IN CRANBERRY REGIONS.

Prof. Henry J. Cox, in charge of the north-central forecast district, with headquarters at Chicago, was authorized to take up a carefully studied project of work in the cranberry marshes of Wisconsin, with a view to obtaining more precise and detailed information concerning the meteorological and soil conditions in that section which shortly precede, accompany, and follow frosts than is obtainable from the ordinary Weather Bureau observations made at relatively widely separated stations. The definite object in view is to establish a scientific basis for more accurate frost prediction for those sections of the country devoted to this special industry.

The equipment of instruments comprised soil thermometers and thermographs, Assmann's aspiration psychrometers,

and ordinary thermographs for recording air temperatures, together with other standard instruments of the usual types. Owing to delays in the delivery of the important instruments purchased in European markets, observations of the late spring frosts could not be made, and on this account the work will no doubt require to be extended longer than was originally contemplated.

RIVER-STAGE INDICATOR.

The vast importance which attaches, in flood seasons, to the stages of large navigable rivers makes an instrument that will indicate at all times, in the local offices of the Weather Bureau at stations situated on these rivers, the exact stage of the water a practical necessity. Heretofore devices of this character have been debarred, not only because of the considerable expense involved in their installation, but also because a suitable form of apparatus at reasonable cost was not on the market. During the past year, however, a form of instrument developed by Professor Marvin was perfected and promises to prove very satisfactory. One was installed at Portland, Oreg., and recently steps have been taken to place a similar instrument at Pittsburgh, Pa.

By the aid of this instrument the official needs only to look at the dial indicator on the wall of his office, from which the stage of the river at that station is quite easily read. The instrument also indicates whether the river is rising or falling.

EARTHQUAKES AND THE RELATIONS OF THE WEATHER BUREAU TO THEIR REGISTRATION.

Attention has been drawn to the scientific observation of earthquakes by the calamity that befell San Francisco on the 18th of April, 1906, and it seems proper at this point to recall briefly the part taken by the Weather Bureau in this direction. As early as 1886, shortly after the great Charleston earthquake, Professor Marvin's first seismoscope was installed at Washington, D. C. This instrument was able to show, by the stopping of a clock, only the time of beginning of certain slight disturbances. At that early date accurate seismographs were not in existence except, perhaps, a few imperfect forms developed by Ewing, Gray, and Milne in Japan. The removal in 1888-89 of the Central Office of the Weather Bureau to its present location resulted in an interruption of the seismic observations. A better seismoscope, also designed by Professor Marvin, but still of very simple form, was installed in 1893, and for many years was practically the only instrument for the purpose in the United States that was diligently maintained in continuous action. In the meantime, however, far more delicate and complete instruments had been developed in Japan and elsewhere, and one of the best modern types, making a complete record of the horizontal motion of the ground, was installed at the Weather Bureau in February, 1903. This is known as the Omori or Bosch-Omori horizontal pendulum seismograph.

A number of distant earthquakes were recorded on this instrument, which was reinstalled in a much improved fashion shortly before the San Francisco disturbance. The great earthquake was admirably recorded at the Weather Bureau, the motion being so violent as to carry the pen off the sheet for a portion of the time, causing a loss of record for about three minutes, after which, as the violence of the motion subsided, the pen resumed its record. The fact that altho no one in Washington could feel the motion of the ground yet the instrument made a record larger than the sheet could contain shows how very sensitive it is to the vibrations of the earth. No other instruments of this character are maintained by the Weather Bureau at the present time, and it seems proper at this place to call attention, very briefly, to certain important considerations bearing upon the question of seismic observations.

It is now well known that the whole crust of the earth is very frequently shaken by earthquakes, and that several thousand disturbances, great and small, occur every year. A complex and difficult geophysical problem is presented in these

phenomena, which are now just beginning to be observed and studied in a systematic manner.

After several preliminary conferences an international bureau of seismology was finally established during the current year, which has been joined by nearly all the principal civilized nations of the world. The part to be taken by the United States Government in this important seismological work is at present entirely unorganized and ill defined, but I desire at this time to point out that the Weather Bureau is prepared and qualified to contribute to this work in an effective manner with but little additional expense. It has numerous stations widely distributed and manned by specially trained and skilful observers. It also employs means for collecting and distributing information that can hardly be surpassed. These circumstances render it proper for the Weather Bureau to undertake the systematic registration of earthquakes by means of instruments of the highest type at a small number of its stations. A considerable number of stations is not necessary for the general international work; ten or fifteen will probably answer every requirement. Conditions most favorable for the installation of seismographs will probably be found at stations where Weather Bureau buildings have been erected.

TELEGRAPH, TELEPHONE, AND CABLE LINES.

The Telegraph Division, under Mr. J. H. Robinson, is charged with all details relative to messages by telegraph and telephone, and the construction and maintenance of lines of communication.

An important addition to the system of Weather Bureau telephone lines and cables on the Great Lakes was made on September 12, 1905, by the laying of a submarine cable from Charlevoix, Mich., to St. James, Beaver Island, Mich., a distance of 33½ miles. A connecting land line 2 miles long was built during June, 1906, from St. James to Church Hill, on the same island. Aside from its main object—the transmission of storm-warning messages to the displaymen at St. James and Church Hill—the cable connection with the mainland is of no little importance to the business interests of Beaver Island.

The telephone line from Grand Marais to Vermillion, Mich., was extended to Whitefish Point, a distance of 10 miles. The entire section is jointly owned and operated by the Weather Bureau and the Life-Saving Service, and affords the sole communication for a chain of storm-warning and life-saving stations on eastern Lake Superior.

The other sections of the Weather Bureau telegraph and telephone lines on the lake and seacoasts were maintained in efficient working order, excepting only the line from San Francisco to Point Reyes Light, Cal., which was partly destroyed by the great earthquake of April 18, 1906.

The receipts from private messages transmitted over Weather Bureau lines amounted to \$3036.84. In addition, \$2101.92 was collected for connecting commercial lines.

REPORTS OF PASSING VESSELS.

A total of 26,818 vessels of all rigs was reported from the several Weather Bureau stations on the Atlantic, the Pacific, and the Gulf coasts direct to the owners, agents, and maritime associations concerned. Special reports of shipwrecks and other marine casualties were made when opportunity offered.

EXAMINATION AND PROMOTION.

Examinations serve two useful purposes: (1) They stimulate systematic study on the part of the younger men; (2) and they afford an index to educational attainments that is of assistance in selecting men for promotion.

In order that they may serve as a mental stimulus, they must be of such character that they can be passed by a majority of those who undertake them, since repeated failures are a discouragement. On the other hand, in order that they may be

useful in selecting men for promotion to important positions, they must be of such character that they will clearly indicate the ability of the person examined. It is to the interest of all concerned that an examination should call attention to deficiencies in education where such exist, since by determined effort such deficiencies can in almost every case be overcome.

It having become evident that examinations heretofore given in English grammar were tests of technical knowledge of the construction of the language rather than ability to use it correctly, the supervising examiner was instructed to include in this examination, in addition to exercises in false syntax, an essay of not less than 500 words, and also to mark the grammatical construction of the answers to the questions in elementary meteorology. The essays thus far graded indicate a very general defect in the style of a majority of the persons examined, in the following respects: (1) The frequent repetition of words; (2) the use of unnecessary words and phrases; (3) faulty arrangement of the parts of a sentence, so that in some cases the meaning conveyed is directly opposite to that which was intended; (4) bad punctuation, long paragraphs, containing several independent ideas, sometimes being written as a single sentence. In general, faulty construction and bad style are more common than glaring grammatical errors. Emphasis is laid upon these facts because it is necessary for assistant observers to write good English before they are fit to take charge of stations and prepare reports for publication.

The following table gives the number of examination papers marked during the year by the supervising examiner, Mr. H. H. Kimball:

Subject.	Date of examination.					Number of employees examined.		
	1905.			1906.		Total.	Passed.	Failed.
	June.	Sept.	Dec.	Mar.	June.			
English grammar.....	6	5	7	31	18	67	52	15
Arithmetic.....	6	4	6	10	7	33	26	7
Elementary meteorology...	5	6	6	9	4	30	24	6
Algebra.....	3	4	7	9	4	27	23	4
Physics.....	3	3	5	5	8	24	20	4
Trigonometry.....	5	5	2	5	8	25	20	5
Astronomy.....	4	2	2	4	3	15	14	1
Plant physiology.....	1	5	3	5	14	14	0
Advanced meteorology.....	1	3	5	2	11	11	0
Total.....	34	29	43	81	59	246	204	42

* One thrown out because of dishonesty in connection with the examination.

OBSERVATORY BUILDINGS.

The Weather Bureau buildings referred to in my last report as being in course of construction at Bentonville, Ark., Burlington, Vt., North Platte, Nebr., Oklahoma, Okla., Springfield, Ill., and a physical laboratory at Mount Weather, Va., have been completed and are now occupied, with the exception of the last, which will probably be completed before July 1, 1907.

It has been found not only economical to the Government but advantageous to the prompt and efficient administration of the Weather Service, at many places, to rent small buildings which provide office rooms and living quarters for the observer. These buildings are usually cottages, and only those having grounds large enough to insure a satisfactory exposure for meteorological instruments are selected. When the observer lives in the same building in which the automatic instruments are installed it insures their having constant attention, and the public can obtain at any time forecasts and information in regard to storms, cold waves, etc. The accompanying list shows the places at which such buildings are rented by the Weather Bureau, the annual rent paid, and the items included in the lease. In nearly every instance the amount of rent paid is less than would be that of office rooms in business blocks. This plan results in further economy to the Government, because the salary paid to an official who is provided with living quarters is less than would be given him if such quarters were not furnished.

The following is a complete list of the buildings owned by the Weather Bureau, with the cost of the land and buildings in each case:

Buildings owned by the Weather Bureau.

Location.	Value of lot.	Value of buildings.	Total value.
Amarillo, Tex.	\$1,255.00	\$6,503.00	\$7,758.00
Atlantic City, N. J.	(a)	6,000.00	6,000.00
Bentonville, Ark.	570.40	5,144.50	5,714.90
Bismarck, N. Dak.	(a)	10,000.00	10,000.00
Block Island, R. I.	1,100.00	7,700.00	8,800.00
Burlington, Vt.	(b)	10,505.95	10,505.95
Cape Henry, Va.	(a)	9,104.25	9,104.25
Columbia, S. C.	3,799.00	9,170.00	12,969.00
Devils Lake, N. Dak.	2,300.00	8,000.00	10,300.00
Duluth, Minn.	2,100.00	7,900.00	10,000.00
Hatteras, N. C.	125.00	4,875.00	5,000.00
Havre, Mont.	1,850.00	5,700.00	7,550.00
Jupiter, Fla.	(a)	6,094.95	6,094.95
Key West, Fla.	2,020.00	7,991.75	10,011.75
Kittyhawk, N. C.	(a)	1,616.00	1,616.00
Modena, Utah.	(a)	4,346.00	4,346.00
Mount Weather, Va.			
Observatory building	2,000.00	18,000.00	20,000.00
Power house and balloon building	650.00	8,000.00	8,650.00
Absolute building	(a)	6,500.00	6,500.00
Variation building	(a)	8,000.00	8,000.00
Kite shelter	(a)	3,000.00	3,000.00
Stable	(a)	2,000.00	2,000.00
Barn	(a)	900.00	900.00
Cottage for workmen	(a)	1,300.00	1,300.00
Mount Washington, N. H.	(c)	300.00	300.00
Nantucket, Mass.	1,236.50	3,968.00	5,204.50
Narragansett Pier, R. I.	4,100.00	8,000.00	12,100.00
North Head, Wash.	(a)	4,000.00	4,000.00
North Platte, Nebr.	(d)	3,818.50	3,818.50
Okla. Okla.	(e)	10,886.35	10,886.35
Peoria, Ill.	54.00	7,915.00	7,969.00
Point Reyes Light, Cal.	(a)	3,000.00	3,000.00
Port Crescent, Wash.	32.00	1,000.00	1,032.00
Sand Key, Fla.	(a)	5,593.00	5,593.00
Sault Ste. Marie, Mich.	(a)	3,000.00	3,000.00
Southeast Farallon, Cal.	(a)	5,211.22	5,211.22
Springfield, Ill.	(a)	10,602.70	10,602.70
Tatoosh Island, Wash.	(a)	5,000.00	5,000.00
Washington, D. C.	25,000.00	150,000.00	175,000.00
Yellowstone Park, Wyo.	(a)	11,500.00	11,500.00
Yuma, Ariz.	(a)	1,500.00	1,500.00
Total	48,241.90	393,649.17	441,891.07

a Government reservation. b Donated by University of Vermont. c Leased.
d Old building bought. e Donated by Epworth University.

Rented buildings occupied wholly by the Weather Bureau.

Station.	Annual rent.	Other items included.
Alpena, Mich.	\$650.00	Heat, light, water.
Anniston, Ala.	475.00	Do.
Charles City, Iowa.	420.00	Do.
Del Rio, Tex.	444.00	Do.
Durango, Colo.	440.00	Heat, cleaner, light, water.
East Clallam, Wash.	120.00	Water.
Flagstaff, Ariz.	300.00	
Helena, Mont.	504.00	Heat, water.
Independence, Cal.	432.00	Heat, light, water.
Kalispel, Mont.	360.00	
Lewiston, Idaho.	540.00	
Manteo, N. C.	144.00	Do.
Moorhead, Minn.	600.00	Do.
Mount Tamalpais, Cal.	420.00	Water.
Pysht, Wash.	144.00	Heat, light, water.
Roseburg, Ore.	550.00	Heat, cleaner, light.
Roswell, N. Mex.	720.00	
Santa Fe, N. Mex.	360.00	
Santo Domingo, West Indies.	480.00	
Thomasville, Ga.	420.00	
Tonopah, Nev.	1,200.00	
Twin, Wash.	100.00	
Williston, N. Dak.	450.00	Heat, cleaner, light, water.
Winnemucca, Nev.	360.00	Heat, light, water.
Iola, Kans.	468.00	Do.

Stations at which observers' quarters are furnished by the Government separate from offices.

Station.	Annual rent.	
	Office.	Residence.
Bridgetown, Barbados	\$240.00	\$240.00
Honolulu, H. I.	480.00	540.00

During the fiscal year beginning July 1, 1906, observatory buildings will be constructed at Anniston, Ala.; Birmingham, Ala.; Charles City, Iowa; Iola, Kans.; Mount Weather, Va.,

cottage and office building; Mount Weather, Va., physical laboratory building²; Sandy Hook, N. J.; Sheridan, Wyo.

It is not practicable, however, to state the cost of the grounds and buildings at these places, because, in most instances, the purchase of the ground has not been consummated and the building contracts have not been let.

CHANGES IN THE FORCE OF THE BUREAU.

CLASSIFIED SERVICE.

Appointments.—One hundred and thirteen permanent appointments were made during the fiscal year—by certification for probationary period, 100 (of which number 49 were assistant observers, at \$720 per annum), at \$360 to \$1250 per annum; by transfer from other bureaus, 4, at \$1200 to \$2000; by reinstatement, 8, at \$360 to \$1000, and by Executive order, 1, at \$3000 per annum.

Temporary and emergency appointments.—There were 37 temporary appointments for periods of less than ninety days, at \$360 to \$1000, mostly station messenger boys, at \$360, whose appointments were made pending the action of the Civil Service Commission to secure eligibles, and 8 emergency appointments, for one to thirty day periods, at \$450 to \$1000.

All temporary and emergency appointments were made under the authority of the Civil Service Commission.

The total number of appointments of all kinds made during the year was 158.

Promotions.—One hundred and eighty-three promotions were made by advancement to the next higher grade.

Reductions.—Necessitated by the public needs or due to change of station assignment requested by employee, 15; because of decreased efficiency, 5; to eliminate the \$1500 and \$1300 grades, 22; for neglect of duty, errors, etc., 13; for speculating, in violation of station regulations, 1; for culpable negligence and irregularity in filing practise forecasts, 1; because of allowances of quarters, fuel, and light, 5; total reductions for the year, 62.

Resignations.—Fifty-two voluntary separations occurred, of which 11 were made to enable the employees to accept positions in other Government bureaus. Sixteen resignations were required—1 for refusing station assignment, 1 because of conflicting public and private interests, 3 for incompetency, 6 for unsatisfactory service, 1 for unsatisfactory conduct and service, 3 for unsatisfactory conduct, and 1 for physical disability; total separations by resignation during the year, 68.

Removals.—For neglect of duty and insubordination, 1; for unsatisfactory service, 2; for shiftless habits and personal misconduct, 1; for absence without authority, 2; for flagrant disobedience of orders, 1; because of insanity, 1; for disobedience of instructions and falsification of records, 1; total 9.

Dropt from rolls at termination of probationary period.—Two probationers were refused absolute appointment because of unsatisfactory service.

Deaths.—Total, 6.

UNCLASSIFIED SERVICE.

Appointments.—Appointments to the unclassified service numbered 10, the salaries ranging from \$240 to \$480 per annum, as follows: For duty at Washington, D. C., 3 (2 thru the board of labor employment and 1 for an emergency period of less than one month); for duty outside the District of Columbia, 7 (1 station agent, 3 student assistants, 3 road laborers).

Promotions.—Four unclassified employees were promoted during the year, each to the next higher grade, the salaries ranging from \$360 to \$720 per annum.

Resignations.—There was one (voluntary) resignation.

Reductions.—One unclassified employee was reduced for using extraneous influence to secure change of station assignment.

² One-half constructed previous year.

Discharges.—Three laborers were discharged as commissioned employees and reemployed as per diem men.

ABSENCES DURING THE CALENDAR YEAR 1905.

Station.—The average absence with pay of station employees (99 per cent being males) during the calendar year 1905 was 1.4 days on account of sickness and 9.1 days on account of annual leave.

Washington, D. C.—The average absence with pay of employees at Washington, D. C. (officials, clerks, mechanics, messengers, and laborers), during the same period was: Males, 3.9 days on account of sickness and 26.1 days on account of annual leave; females, 2.8 days on account of sickness and 27.8 days on account of annual leave.

The general average of the entire service, station and Washington combined, was 2.1 days on account of sickness and 13.8 days on account of annual leave.

STATISTICS OF THE SERVICE.

The following tables show the numerical strength of the Bureau and the highest and lowest salaries paid in the classified and unclassified grades:

Numerical strength of the Weather Bureau, June 30, 1906.

At Washington, D. C.:	
Classified	172
Unclassified	11
Outside of Washington, D. C.:	
Classified	496
Unclassified	17
Total commissioned employees	
513	
Additional employees outside of Washington, D. C.:	
Storm-warning displaymen	164
River observers	340
Cotton-region observers	144
Corn and wheat region observers	133
Rainfall observers	107
Sugar and rice region observers	9
Total noncommissioned employees	
897	
Total paid employees	
61,593	
Persons serving without compensation (except thru the distribution of Government publications):	
Cooperative observers	c3,683
Cooperative storm-warning displaymen	d71
Weather correspondents	e4,841
Total numerical strength	
8,595	

Distribution of the commissioned force, June 30, 1906.

In Washington, D. C.:	No. of employees.
Accounts Division	12
Climatological Division	7
Review Room	3
Executive branch	f17
Forecast Division (including River and Flood Service)	13
Division of Ocean Meteorology	7
Instrument Division	10
Library	3
Division of Meteorological Records	17
Miscellaneous Mechanical Work	5
Publications Division	43
Supplies Division	g10
Telegraph Division	11
Captain of the Watch (under direction of the Chief Clerk) ..	25
Total	
183	

Outside of Washington, D. C.:

64 stations with 1 employee	64
50 stations with 2 employees	100
36 stations with 3 employees	108
19 stations with 4 employees	76
12 stations with 5 employees	60
6 stations with 6 employees	36
4 stations with 7 employees	28
3 stations with 8 employees	24
1 station with 9 employees	9
2 stations with 11 employees	22

197 stations **h527**

In addition to the above, there are seven one-man stations in the West Indies, in charge of noncommissioned employees (generally agents of cable companies).

Salaries paid in the classified and unclassified grades.

Grades.	June 30, 1906.	
	Station.	Washington, D. C.
CLASSIFIED GRADES.		
Highest salary	\$3,000	\$5,000
Lowest salary	360	450
Average salary	986	1,207
UNCLASSIFIED GRADES.		
Highest salary	720	720
Lowest salary	300	240
Average salary	384	492

Average salary for all (station and Washington, including the Chief of Bureau), \$1,028.

The foregoing table of salaries does not include employees on duty at substations (storm-warning displaymen, river observers, etc.) whose compensation ranges from \$5 to \$20 per month, and whose tour of service averages less than one hour a day; and it does not include seven station agents in the West Indies, each averaging about \$25 a month.

RECOMMENDATIONS.

It is recommended that four additional Weather Bureau stations be created and that for this purpose \$10,000 be added to the fund "Salaries, Weather Bureau," and also that \$10,000 be added to the fund "General Expenses, Weather Bureau," with \$5000 additional to provide for the gradual increase of telegraphic expense at the existing stations of the Bureau. Two additional clerks are recommended for duty at the Central Office to perform the additional work entailed upon the Bureau by the creation of new stations and the increasing demands for additional reports.

An appropriation of \$22,000 is also recommended for the purchase and the laying of a cable to connect Devils Island, Minnesota, with the mainland.

a This total represents an increase of 16 over the number reported June 30, 1905, and is exclusive of 16 employees on furlough for three months or more on June 30, 1906.

b This total embraces all paid employees in the Bureau on June 30, 1906, including the Chief of Bureau, but excluding employees on furlough for three months or more.

c The 1771 cooperating vessels mentioned under "Ocean Meteorology", and representing a larger number of observers, are not included in these statistics.

d Twenty of these cooperative displaymen are employed in other branches of the Government service.

e About 75 per cent of this number also serve as cooperative observers. This decrease from the report of 1905 is due to dispensing with the services of a large number of weather crop correspondents, rendered unnecessary by the elimination of the crop feature from the weather bulletins.

f Two men devote half their time elsewhere.

g Plus one-half the time of one man.

h This number represents the normal regular force. On June 30, 1906, there were actually on duty only 513 employees.